

Section 6:SEISMIC DESIGN

6.1 Introduction. This Section provides criteria for permanent military health care facilities. Base seismic design requirements upon the level of operation, or seismic performance objective, as defined in TI 809-04, required for a particular health care facility following an earthquake. Seismic performance levels vary from life safety (intended to reduce the likelihood of injury and loss of life) to a complete post-earthquake operational capability (defined as immediate occupancy in TI 809-04). The required level of seismic performance for a facility will be as directed by the Contracting Officer, determined in coordination with the Design Agent and the Using Military Department Representative for a specific project.

6.2 Health Care And Design Requirements. The designation of seismic performance objective for a particular health care facility will depend upon the seismic use group, the seismic performance level, and the level of design ground motion as defined in TI 809-04. Certain health care facilities may require only key areas to be operational after an earthquake. Other health facilities may require only a life safety level of performance. Design requirements may include the preservation of essential utility systems such as ventilation, electricity, water supply, waste systems, steam distribution, medical gases, vacuum, medical air, and communications. Design utility systems to permit isolation of damage by shutoff of damaged areas and operation of systems at a reduced capacity.

6.3 Seismic Performance Levels. The Using Military Department will determine based upon criticality of facility function the performance level required for a medical facility. The following levels of seismic performance are defined with respect to operational mission, disaster preparedness and medical post-earthquake needs:

6.3.1 Life Safety Level. This level, which generally applies to existing health care facilities, is the minimum requirement of seismic upgrade or alteration projects. The essential requirement is to reduce the likelihood of injury or death to personnel by providing a structure with a margin of safety against collapse. Existing health facility structural systems will be evaluated according to the requirements in TI 809-05 as given in Section 5, Structural Design. This evaluation will also include both geologic site hazards and the anchorage and lateral support of mechanical, electrical, architectural and other non-structural elements whose damage will threaten the life safety of occupants or might block safe means of egress. When an existing Structural Design system does not meet these requirements, the system will be strengthened according to the requirements in TI 809-05 as given in Section 5, Structural Design. With this level of design, the health care facility requires post-earthquake evacuation, with post-earthquake medical operations dependant upon outside assistance. No specific time is specified for re-occupancy and utilization for this class of structure.

6.3.2 Partial. The partial operational level, which is equivalent to a safe egress Structural Design performance level as defined in TI 809-04, may apply to either new or existing facilities. These requirements will generally apply to new facilities to be located in areas where the design spectral response acceleration at short periods (S_{DS}) is less than 0.167 and for existing facilities where the design spectral response acceleration at short periods (S_{DS}) is greater than 0.167 but less than 0.33. In this category, critical spaces, laboratories, radiology, CMS, supply storage, and Nuclear Medicine must be designed to continue in operation following a design earthquake. In those areas, fixed equipment, vertical transportation, and

utilities shall be anchored/braced to resist the seismic forces, and if damaged, be restorable within several days. Facilities with this design level will continue operation with outside assistance for inpatients and disaster victims with temporary expansion of emergency facilities.

6.3.3 Selected/Full. This level of design, which is equivalent to an immediate occupancy Structural Design performance level as defined in TI 809-04, provides a higher level of seismic resistance capability than the "Partial" level. This level of seismic performance will generally apply to new facilities located in areas where the design spectral response acceleration at short periods (S_{DS}) is greater than 0.167 but less than 0.50. Health facilities with a full level of seismic performance will be designed to be prepared for post-earthquake operations and capable of restoration of minor damage within several hours following the maximum design seismic ground motion. All utilities and equipment must be prepared for isolation and/or restoration with minimum work when damage occurs. Provision for temporary emergency connection or augmentation of potable water, sanitary sewers and fuel will be required. In existing facilities where upgrade of all portions of the facility is economically impractical, upgrade may be restricted to the more critical spaces and systems identified in the program authority document.

6.3.4 Complete. The complete level of seismic resistance, which is equivalent to an immediate occupancy Structural Design performance level as defined TI 809-04, is the maximum level of seismic design for military health care facilities. This complete level of seismic performance applies to facilities located in areas with a high seismic risk, i.e., areas where the design spectral response acceleration at short periods (S_{DS}) is greater than 0.50. At this level, the facility will be designed for complete continuity of operation, for medical care of inpatients and for receiving earthquake casualties. Additionally, provisions for emergency supply and capability to operate a hospital immediately after a disastrous earthquake for at least a 4-day period will be made, i.e., water supply, electrical generation, fuel storage, and sanitary facilities. All site utilities and systems which are dependent upon outside sources during normal operations must be completely restorable within a 4-day period. Isolation and damage control will be provided to completely restore the facility to a near normal interior environment within several hours.

6.4 General Design Considerations. Seismic design for a health care facility requires consideration of the site geologic site hazards and ground motions, building configuration, Structural Design systems, spatial allocation, design of glazing, exterior facings, functional space utilization, mechanical systems, electrical systems, communication systems, interior partitions, finishes, and furnishings. Base design for seismic conditions on the seismic use group, the level of seismic ground motion at the site, and seismic performance level, all as defined in TI 809-04. See Section 5, Structural Design for other seismic considerations related to building layout and performance.

6.5 Post-Earthquake Emergency Status. The disaster magnitude and the estimated duration of the post-earthquake emergency period must be reviewed and their impact on the operations of the facility assessed. The extent of curtailment, relocation, and expansion of services; the demands placed on on-site storage of potable water, fuel, sewage, and medical supplies; and the best design solutions to achieve and preserve functionality will be determined from these estimates.

6.6 Concept Design Development. Seismic design will be functional and responsive to the normal operation of the facility. Because each seismically designed facility is unique, specific project criteria for various facility and health systems will be developed during concept design development. The type of Structural Design framing to be used must be coordinated in the early concept development of the functional layout so that an effective, structurally efficient seismic resistance/performance type "system" is considered. Specific project criteria will include mechanical, electrical, medical gases and communication systems design criteria. See Section 5, Structural Design, for the functional and other operational items that must be considered during the development of the building layout and concept design and for the criteria that must be used in the seismic design of the facility.

6.7 New Health Facilities.

6.7.1 Site Planning. Seismic requirements affect site planning to a certain degree. The special studies of site conditions and soil investigations related to geologic hazard identification and site-specific ground motion determinations, are given in Section 5, Structural Design, of this Military Handbook.

6.7.2 Structural Design Planning. The seismic issues related to the selection and development of Structural Design seismic force resisting systems, including the consideration of innovative systems (base isolation and passive energy dissipation systems), of a health care facility building are given in Section 5, Structural Design, of this Military Handbook.

6.7.3 Seismic Design Concept Report. The Designer will prepare and submit this report as required in Section 5, Structural Design. The Seismic Design Concept Report will summarize the seismic design provisions incorporated in the Final Concept Submittal. The objective is to make sure that these provisions meet the designated seismic performance level required to operate the facility. The report must include, but will not be limited to, the following requirements.

a. Seismic design assumptions employed, fire protection, daily water requirements, electrical requirements, mechanical requirements, sanitary facilities, and site access.

b. The location and relationship of departments and essential services under normal and post-earthquake operating conditions.

c. Explanation of how functions are curtailed, relocated, or expanded.

d. Location of major fixed and movable equipment.

e. Description of the Structural Design system selected for resisting lateral force, discussion of reasons for its selection and explanation of how the system will transfer seismic loads to the earth.

f. A list of actions taken to accommodate the major seismic considerations.

g. The geotechnical report document, which will contain the assessment of the geologic site hazards and, when directed, the seismic site-specific ground motion characteristics at the site. This report must include, but not be limited to evaluation of regional geology, seismology, local

geology and soil conditions; past historical earthquake data; and statistical methods used for calculation in determining the design seismic ground motion.

6.8 Evaluation of Existing Health Facilities. Determination of the economical feasibility of seismic upgrade requires that the facility be systematically evaluated, functional priorities established, and rehabilitation measures and costs estimated before a decision is made regarding the post-earthquake role to which the facility should be upgraded. The approach to evaluating a facility will vary depending on several factors: the level of seismic activity expected, age of the facility, type of construction, and the number and configuration of buildings. Upgrade of all portions of an existing facility and all of its systems to current seismic criteria is usually not feasible or practical. Typically economic feasibility limits upgrade to life safety performance levels.

6.8.1 Seismic Hazard Evaluation Considerations. The following elements should be considered in the overall evaluation.

6.8.1.1 Site Hazards Assessment. An assessment of geologic hazards at the site will be done as indicated in Section 5, Structural Design.

6.8.1.2 Structural Design System Evaluation. The seismic hazard evaluation of an existing health care facility buildings Structural Design system, including when an evaluation must be done and the criteria that will control the evaluation, are given in Section 5, Structural Design.

6.8.1.3 Architectural Considerations. Buildings with irregular layouts and configurations (such as U, L, T, E, H, or cross-shaped buildings) or buildings with major setbacks are difficult to strengthen and potentially hazardous and may be cost prohibitive. Overhangs, unbraced parapet walls, gables, balconies, terra-cotta roof tile, and rigidly mounted glazing are hazardous and endanger life safety. The following interior features must also be evaluated:

a. Ceiling systems, in particular lay-in acoustical ceilings, are extremely vulnerable to earthquake motions and forces.

b. Partitions and walls in relatively flexible buildings must be checked, because provisions usually have not been made to prevent interaction between the frames and partitions.

c. Egress doors, which are normally closed, tend to be immobilized by binding the door frame during an earthquake. Their construction details must be carefully reviewed to determine whether their operation will be impaired.

d. Light fixtures and methods of suspension must be checked, because pendant fixtures and fixtures recessed in lay-in acoustical ceilings are particularly vulnerable.

e. Stairwells which are the only method of communication between floors and vertical egress within the facility following an earthquake must be checked. Structural Design adequacy of exterior stair tower structures attached to the main structure to prevent separation during seismic shock must also be checked.

6.8.1.4 Fire Protection Considerations. Evaluate the site water supply system, including its vulnerability to earthquake damage, points of on-site

and public water supply, on-site water storage capacity, sizes and quality of on-site fire mains, fire pumps sizes, capacities, and pressures, and types of supply to buildings. Evaluate the fire protection system, noting extent and quality of sprinkler systems, dry standpipes, wet standpipes, and portable extinguishers.

6.8.1.5 Hazardous Materials. Evaluate bulk oxygen storage, fuel storage facilities and the natural gas supply for earthquake vulnerability and damage. Evaluate the methods of bracing or anchoring medical and/or flammable gas cylinders and the methods of storing laboratory reagents, radioactive isotopes, and other dangerous chemicals.

6.8.1.6 Electrical Power. Electrical power will be assumed to be unavailable from public utilities following an earthquake. Determine the availability, capability and capacity of the alternate power source (on-site generator(s)) to provide the necessary power to operate the facility following an earthquake. Make particular notes of all pertinent characteristics of the alternate power source, with emphasis on capacity, mounting arrangement, starter reliability, fuel supply, age, and degree of automation. Also note the general vulnerability to earthquake-induced damage of the transfer switches, electrical distribution system, and items to be serviced by the alternate source power system.

6.8.1.7 Mechanical Systems & Equipment. Inspect the boiler plant to determine the type of construction, type of boilers, anchorage of boilers, bracing of critical piping, and the location, type, and mounting of critical auxiliaries. Evaluate the domestic cold water systems for bracing of main lines, storage tanks, and distribution points. Inspect all mechanical rooms and critical equipment (such as heating, ventilating and air conditioning equipment) for methods of anchorage, mounting, and bracing. Check required connections to other equipment elements.

6.8.1.8 Site Accessibility. Evaluate public access to the facility. Provide at least two separate on-site entrance roads to the facility, each preferably connecting to a different off-site public access road. Identify potential earthquake hazards to roads, bridges, overpasses, and retaining walls. Inspect the site to determine if a safe and reliable on-site space for emergency helicopter landings is within close proximity of the hospital buildings.

6.8.1.9 Facility Upgrade Report. Include all of the above considerations, along with the Structural Design system evaluation and the site hazards assessments, in a facility upgrade report (SEE SECTION 2)

6.8.2 Final Evaluation. Based on the review and approval of the seismic facility upgrade report, a final evaluation of the facility will determine the most satisfactory method to upgrade the seismic resistance to the prescribed criteria. Proposed solutions will be thoroughly analyzed and cost estimates prepared. As an alternate concept, a base isolation system may be considered to upgrade the seismic resistance of facility. Base isolation will limit the seismic forces transmitted to the super structure and minimize the seismic upgrade provisions for the non-structural elements. If considered, the base isolation requirements for new medical facilities apply.

6.9 Design of Essential Non-structural systems. The seismic restraint, protection, site-storage, and other seismic design features and requirements addressed by the following criteria will be applicable according to the level of the seismic threat and the designated operational level of the facility.

6.9.1 Identification of Essential Systems. Table 6-1 identifies essential non-structural systems and lists them in order of priority based on previous post-earthquake experience and input from professional health care personnel.

6.9.2 Life Safety Systems.

6.9.2.1 Fire Sprinkler Piping. Brace sprinkler system piping in accordance with details provided in NFPA 13.

6.9.2.3 Portable Fire Extinguishers. Provide mounting brackets for hung and free standing portable fire extinguishers, designed to preclude inadvertent release of the extinguisher due to vertical or horizontal earthquake motions.

6.9.2.4 Standpipes. Brace wet and dry standpipes.

6.9.2.5 Fire Pumps. Protect pumps to avoid damage by falling debris.

6.9.2.6 Stairways. Design stairways to resist required lateral loads and insure tolerance to maximum predicted structural design deformations.

6.9.2.7 Exit Doors. Design exit door frames so they will not deform and jam as a result of seismic forces.

6.9.2.8 Exitways. Plan exits and exit pathways to avoid blockage with debris from ceilings, brittle wall finishes, and glass following a seismic disturbance.

6.9.3 Hazardous Materials

6.9.3.1 Special Storage Provisions. Provide special storage equipment or accessories that are convenient for normal daily use, and functional after earthquakes. Examples of such equipment are lower profile shelves with face bars which restrain material on shelves and secure shelves to the wall or floor; specially designed racks for restraining reserve oxygen and nitrous oxide tanks; and special bins for storing anesthetic gas containers.

6.9.3.2 Fuel Gas Piping. Brace piping and provide shutoff valves. Use malleable fittings and valves, provide swing joints where necessary.

6.9.4 Electrical Systems.

6.9.4.1 General. The Essential Electrical System will follow the requirements outlined in Section 10, Electrical, of this Military Handbook.

6.9.4.2 Vibration Isolation. Where vibration isolation is not required, bolt generators directly to an appropriate foundation. Where vibration isolation is necessary, provide restraining clips at vibration isolators to prevent failure of the isolation mountings under earthquake vibration conditions.

6.9.4.3 Generators. Where practicable, use generators with integral radiator cooling systems. Where auxiliary cooling systems are necessary, install cooling towers or remote radiators at grade level. Brace cooling towers or radiators and provide special bracing for piping.

6.9.4.4 Fuel Storage Tanks. Underground Fuel Storage Tanks are required. Install expansion flex loops in fuel lines which are on the soil side of a foundation. Anchor all fuel day tanks, using malleable fittings and valves, with flexible connections to the generator.

6.9.4.5 Battery Racks. Anchor and brace battery racks.

6.9.4.6 Miscellaneous Electrical Equipment. Anchor or restrain switchgear, substations, automatic transfer switches, distribution panels, and motor control centers. Give special attention to providing adequate support for bus ducts.

6.9.4.7 Building Expansion (Seismic) Joints. Carefully design all crossings of seismic or expansion joints by power lines. Flexibility of cable and conduit at potential points of differential movement will be provided, as will separate grounds for conduit runs crossing seismic joints.

6.9.5 Conveyance Systems. Design elevators and shafts to meet the prescribed lateral force requirements. Evaluate elevator manufacturers' recommendations for meeting these criteria. In general, it will be necessary to install additional rail support brackets, counterweight retaining brackets, rail safety shoes and emergency stop gear; and to brace spreader beams and elevator control cabinets.

6.9.6 Mechanical Systems. Mechanical equipment, including distribution piping and ductwork, shall be braced, anchored, or otherwise protected in accord with the criteria for the designated seismic performance level of the facility. Designers are required to coordinate the bracing of piping systems subject to thermal expansion with the seismic restraint system, to assure both systems function as intended.

6.9.6.1 On-Site Sanitary and Water Storage Facilities. For any facility with a designated seismic protection level in excess of "Life Safety", the following criteria shall apply.

a. Provide the water service with two independent connections to the water system. In addition, provide a water storage facility as a source of supply, sized to adequately meet fire and water demands during the post-earthquake emergency period. Design water mains to minimize service disruption from earthquakes and to facilitate post-earthquake repair. Domestic water storage considerations may factor in a reasonably reduced level of water consumption for the emergency period of operation.

b. Provide an Emergency Sanitary Sewage Holding Facility for temporary retention of all sanitary sewage discharge from the hospital during the post-earthquake emergency period.

6.9.6.2 Fuel Gas Shutoff Valve. Equip the site gas supply line with a safety shutoff valve.

6.9.7 Medical Systems and Equipment.

6.9.7.1 Autoclaves. Anchor steam sterilizers.

6.9.7.2 X-Ray Equipment. Include bracing as required for the design of X-ray unit ceiling tracks. Anchor X-ray control consoles and automatic film developers.

6.9.7.3 Miscellaneous Equipment Considerations

a. Secure equipment or shelving not required to be moved from location to location to a partition. Equipment with doors should have a positive latching device that operates automatically when access to the equipment or shelving is not continuously required.

b. Blood bank, drug storage, critical refrigerators, freestanding incubators and centrifuges, should be secured.

c. Secure sequential multiple blood analyzers and other fragile laboratory equipment. Anchor related shelving, and provide lips and face bars as necessary.

d. Wheeled Equipment. Wheeled equipment should have wheel locks and should be assigned a specific location when not in use. Wheeled equipment should be provided with closets or alcoves, whenever possible, to limit rolling. Portable equipment should be stored in recessed cabinets which are secured to partitions, whenever possible.

6.9.7.4 Supply Storage. Supply cabinets should have either plastic or tempered glass in sliding doors, and the doors should slide closed automatically. Open shelving should have a shelf rim which precludes supplies being shaken from their storage position.

6.9.7.5 Medical Gas Bottles. Metal boxes attached to the floor and equipped with double chains should be provided for medical gas bottles. Wheeled carts carrying oxygen or other medical gases should be equipped with wheel locks and chains for fastening to walls.

6.9.8 Architectural Systems.

6.9.8.1 Lighting Fixtures. Provide independent hangers at diagonal corners of lighting fixtures installed in suspended ceilings. Avoid use of pendant fixtures; if used, they will be of earthquake-resistant design. Use positive locking devices to install surface-mounted and recessed fixtures.

6.9.8.2 Ceilings. Avoid the use of large areas of lay-in type acoustic ceilings. Such ceiling construction is not inherently earthquake-resistant and will become progressively less earthquake-resistant due to failure to replace hold-down clips during maintenance procedures. Avoid the use of these ceilings in egress and triage areas. Where such ceilings are used, use lateral bracing and runners tied with wires rather than clips. Do not attach the ceiling to the surrounding walls.

6.9.8.3 Computer Room Floors. If computer room floors are used, they will be adequately braced to resist seismic motion.

6.9.8.4 Partitions. Provide appropriate backing plates, blocking, studs, blocking and bracing for partitions which support cabinetry, storage racks, shelves, bins, and lockers. In a relatively flexible building, limit partition damage due to interaction with the frame by anchoring each partition to a single Structural Design member and allowing movement at the other edges.

6.9.8.5 Facing Materials. Brittle facing materials such as ceramic tile or glazed masonry suffers extensive damage during earthquakes and will be used only when necessary to meet medical functional requirements.

6.9.8.6 Windows. Consider story drift when detailing window frames and exterior wall panels.

6.9.8.7 Overhangs. Do not use unbraced overhangs, parapets, and balconies.

TABLE 6-1

ESSENTIAL NONSTRUCTURAL SYSTEMS

1. Fire Protection System
Sprinkler System
Risers
Distribution mains
Valves
Support hangers, bracing, and clamps
Extinguishers
Receptacles
Mounting brackets
Standpipes
Mains
Exits
Stairways
Doors
Corridors
2. Hazardous Materials
Hazardous Systems
Natural gas, O ₂ , N ₂ O
Risers
Distribution mains
Hangers
Hazardous Storage
Radioactive storage
O ₂ Cylinders/Storage tanks

TABLE 6-1
(continued)

ESSENTIAL NONSTRUCTURAL SYSTEMS

N ₂ O Cylinders
Chemicals, reagents
Anesthetic gases
Fuel
3. Alternate Source Power System
Transfer switches
Diesel-Generator
Fuel piping
Cooling System
Cooling tower
Pumps
Piping
Batteries
Controls
Switchgear
Substation
Distribution Panels
Motor Control Centers
4. Communications Systems
5. Transport Systems
6. Mechanical Systems
HVAC Systems
OR and DR
ICU and recovery
Nursery
Ductwork
Air handling units

TABLE 6-1
(continued)

ESSENTIAL NONSTRUCTURAL SYSTEMS

7. Medical Systems
Fixed
Autoclaves
X-ray
Film developers
Sequential multiple analyzer
Casework and exhaust hoods
Portable
Freestanding or wheels
Dialysis units
Appliances
Laboratory/medical equipment
Medical monitoring equipment
Beds, food service units, stretchers, carts
Medical Stores and Supplies
Medications and Drugs
Chemicals
Instruments
Linens
General supplies
Medical Records
8. Architectural Systems
Lighting Fixtures
OR, DR, emergency
Partitions, Ceilings and Walls
Ornamentation
Office Equipment

TABLE 6-1
(continued)

ESSENTIAL NONSTRUCTURAL SYSTEMS

Operation Blocking Hazards
Emergency lighting/batteries
Surgical
Personnel hazards
Glazing and Fenestration
Storage Racks, Bins, Lockers
Egress corridors
Maintenance/Repair Stores and Supplies
Maintenance/repair parts
Housekeeping supplies
Emergency tools
9. Special Equipment
Proximity to Critical Equipment
Expensive Equipment
Non-Emergency Power
Sewer
Kitchen Equipment
Laundry Equipment